Headquarters U.S. Air Force

Integrity - Service - Excellence

Measuring Performance: An Overview

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29 January 2001

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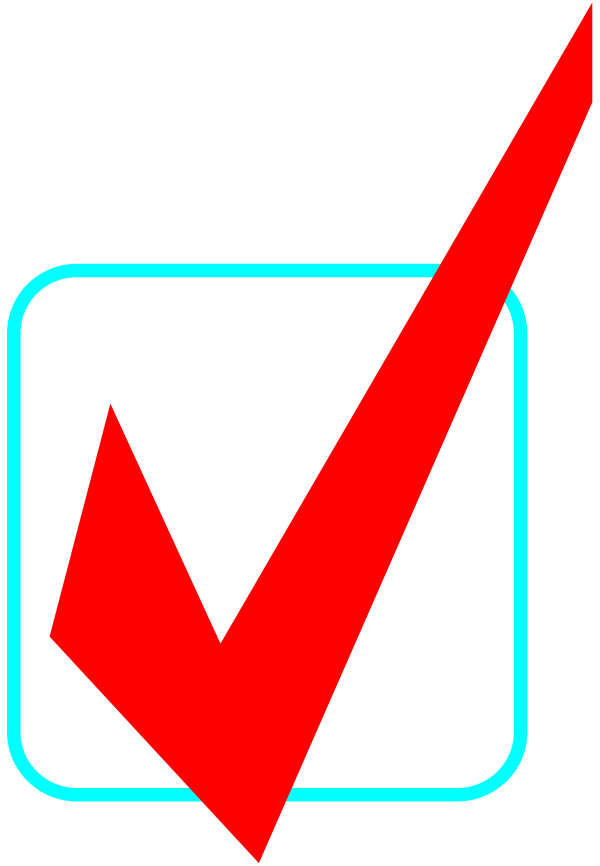
General Overview

- General principles and practices
- Specific technologies

- Indicates Rules of Thumb (throughout the briefing)

Principles and Practices

- **Strategy and planning**
- **Measuring performance**
- **Analyzing performance**



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Strategy

- Keep it Simple Stupid (KISS)
- Just right (optimal)
  - Not too many
  - Not too few
- Must be consistent w/conceptual site model

↯ Strategize how to get what you need, and save time & costs

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Planning

- Previous knowledge of site-characterization data
- Need systematic planning process
  - Sampling plan, SOPs, and QAPP
  - DQOs, but really decision/data optimization (Focus on inputs needed to make a decision)
  - Decision/exit rules for streamlined decision making, including decision trees

↯ Understand what you are doing or ***do not*** do it

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Planning (Continued)

- **Where is it?**
- **What is it?**
- **How is it measured?**
- **“Where” and “what” are very important**
  - **Need representative samples to analyze**
  - **Performance vs. Compliance vs. Process (generally during process, as well as before and after)**
  - **Optimize number of points and frequency**
  - **Use shortened method analyte lists**

If you don’t *need* it, don’t *measure* it

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Planning (Concluded)

- How to measure
  - Screening vs. definitive data
  - Field vs. laboratory methods
- Questions to answer for measuring
  - Is method applicable and reliable?
  - Is analyte detectable at the target concentration?
  - Are results certifiable and acceptable?
  - Is it cost-effective?
  - Should I use shortened method analyte lists?

↯ If you can reliably measure it in the field, ***do it***

Doing It--Sampling

- Location + # of samples + frequency = Just Right
  - Some mandated, others optional
- Sampling methods
  - Groundwater (GW): minimum draw-down
  - GW: diffusion or profile sampler
  - Gas and process: purge as necessary, then grab
  - Soil: grab or composite
- Understand rationale behind each sample

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Doing It--Analysis

Screening Data

- Immunoassay kits
- X-ray fluorescence (XRF)
- Hand-held survey instruments and counters
- Indicator tests
- Fiber-optic chemical sensors
- Infrared spectroscopy (IR)
- Laser-induced fluorescence (LIF)

Definitive Data

- EPA methods
- ASTM methods
- NIOSH methods
- Some proprietary and performance-based methods
- XRF
- Some survey counters (radionuclides)
- Others?

Analyzing Performance

- **Tools**
  - **Data Assessment**
    - **Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC)**
    - **Initial focus on representativeness and comparability, especially when screening is combined w/definitive data**
    - **Then precision, accuracy, and completeness**

- **Always use some field replicates and matrix spiking to estimate precision and accuracy for the actual samples**

Analyzing Performance (Concluded)

- Tools (Concluded)
  - Computer models
    - Outputs both mathematical and visual
    - Used for "Just Right" approach
  - Statistical
    - Histograms
    - Control charts
    - Tabular
  - Visualization
    - Maps: plume and distribution
    - Trend plots over time

- If performance can be shown visually, *do it*

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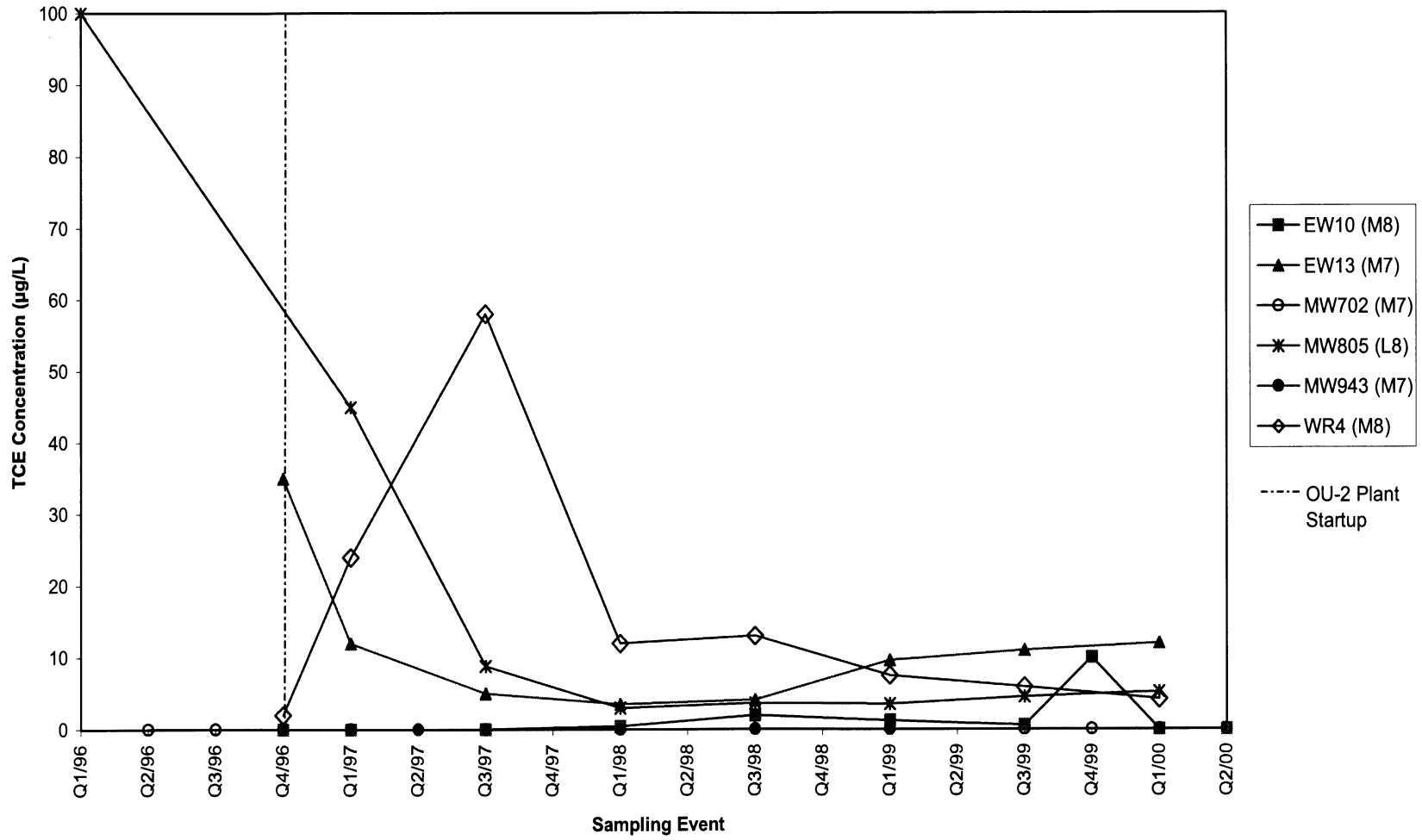
Example of Trend Chart: TCE in GW over 4 years



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Principles & Practices Summary

- Plan with the *end in mind*
  - Curtailment
  - Exit strategy and rules
- Always use DQO-type process—decision rules
- Collect data to make the decision (Just Right)
- KISS
- Measure it in the field
- Take samples that are representative
- Keep analysis of performance visual
- Understand why you are doing it or do not do it

Specific Technologies

Innovative

- Permeable Reactive Barriers *
- Phytoremediation *
- Bioremediaton *
- Monitored Natural Attenuation *

Standard

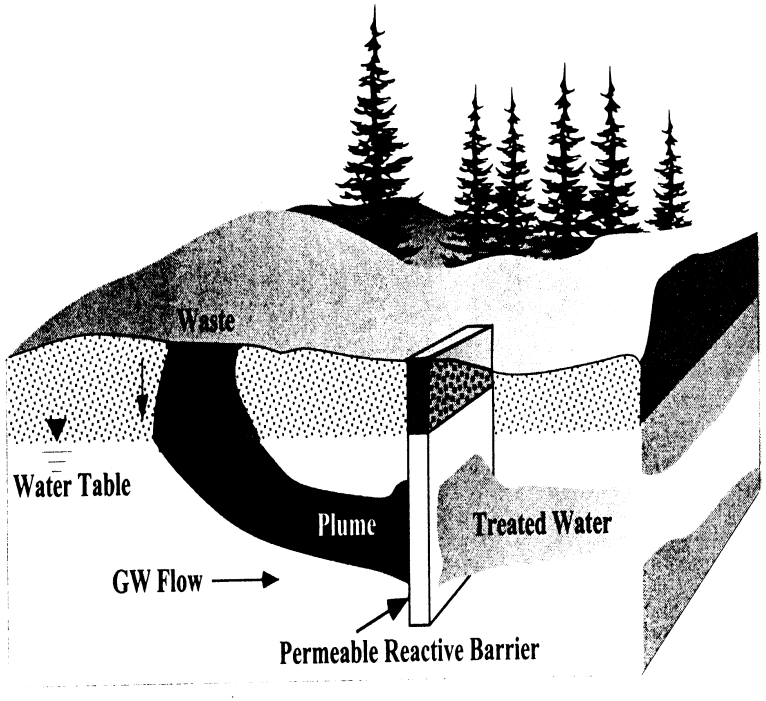
- Soil Vapor Extraction
- Pump & Treat
- Dig and Haul
- Landfill Cover *

Issues for each:

- Where and what to measure
- What to expect
- Tricks
- Rules or recommendations

*** To be discussed in greater detail on Days 2 & 3**

Specific Technologies: Permeable Reactive Barriers



- Where to Measure
  - Compliance: GW at perimeter or guard wells
  - Performance: GW in flow path before and after reactive barrier
    - may need wells in inderlying unit
    - may need horizontal and vertical groundwater profiles

Specific Technologies: Permeable Reactive Barriers (Continued)

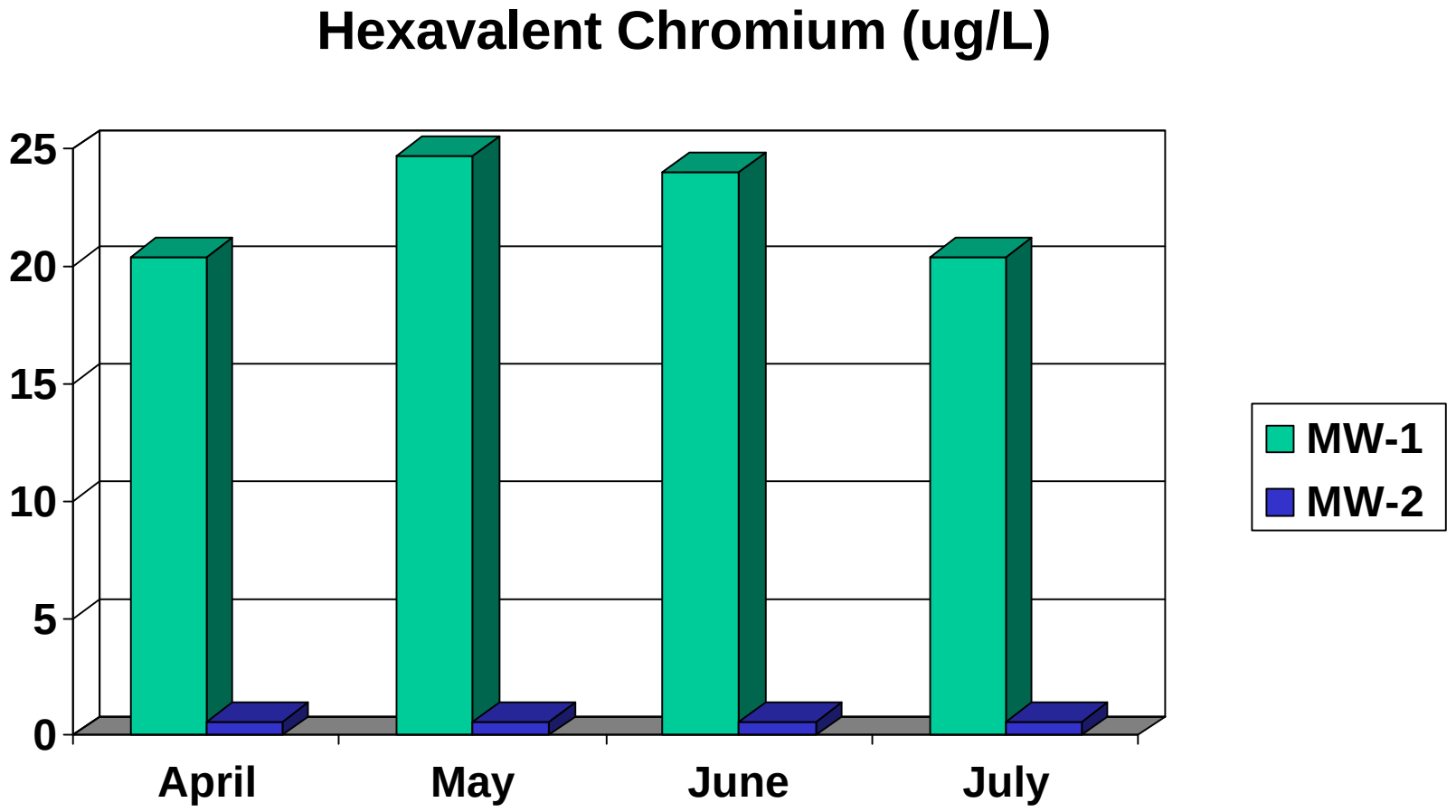
- **What to measure (GW)**
  - **Depends on barrier type (reaction or sorption)**
  - **Specific contaminant and/or reaction by-products**
  - **Examples are Cr^{6+}, TCE and ethene**

- **What to expect**
  - **Changes in concentrations [C] after barrier is in place**
  - **Reaction capacity may change over time**

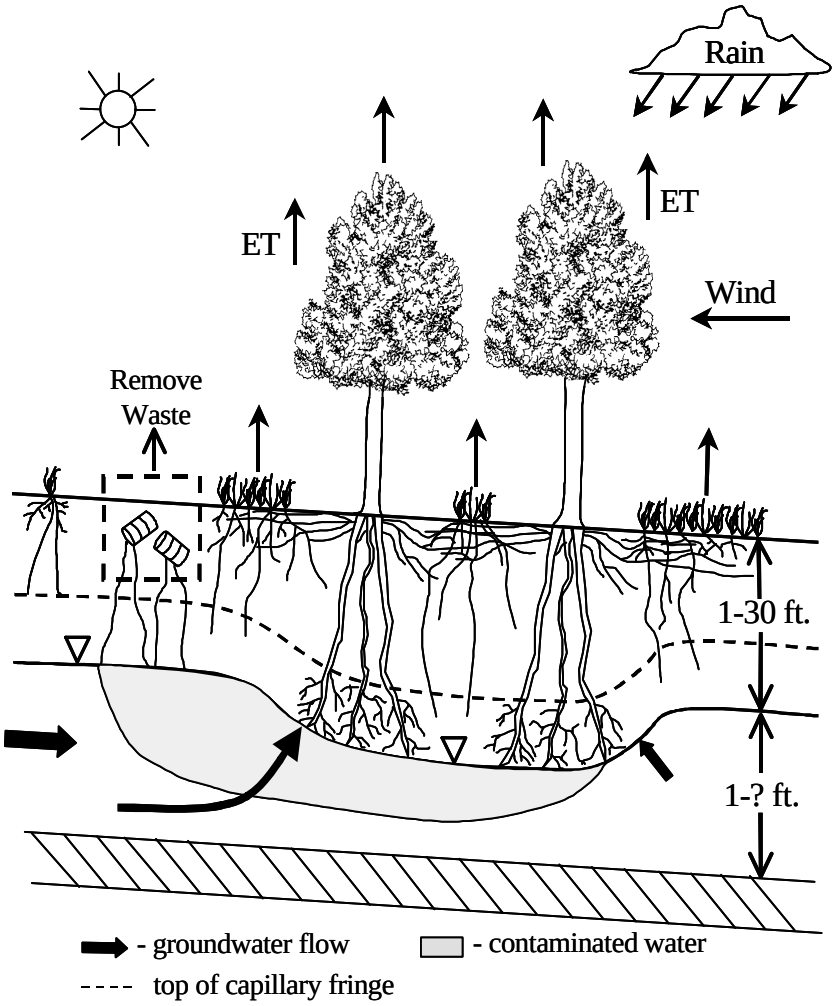
Specific Technologies: Permeable Reactive Barriers (Concluded)

- Tricks
  - Suitable for field measurements, with some laboratory measurements
  - Consider vertical profile or diffusion sampling
- Rule
  - Should be uncomplicated data interpretation
    - Example: If Cr^{6+}(in) is much greater than Cr^{6+}(out) or if Cr^{6+}(out) is not detected, the system is working

Visualized Example: Permeable Reactive Barrier



Specific Technologies: Phytoremediation

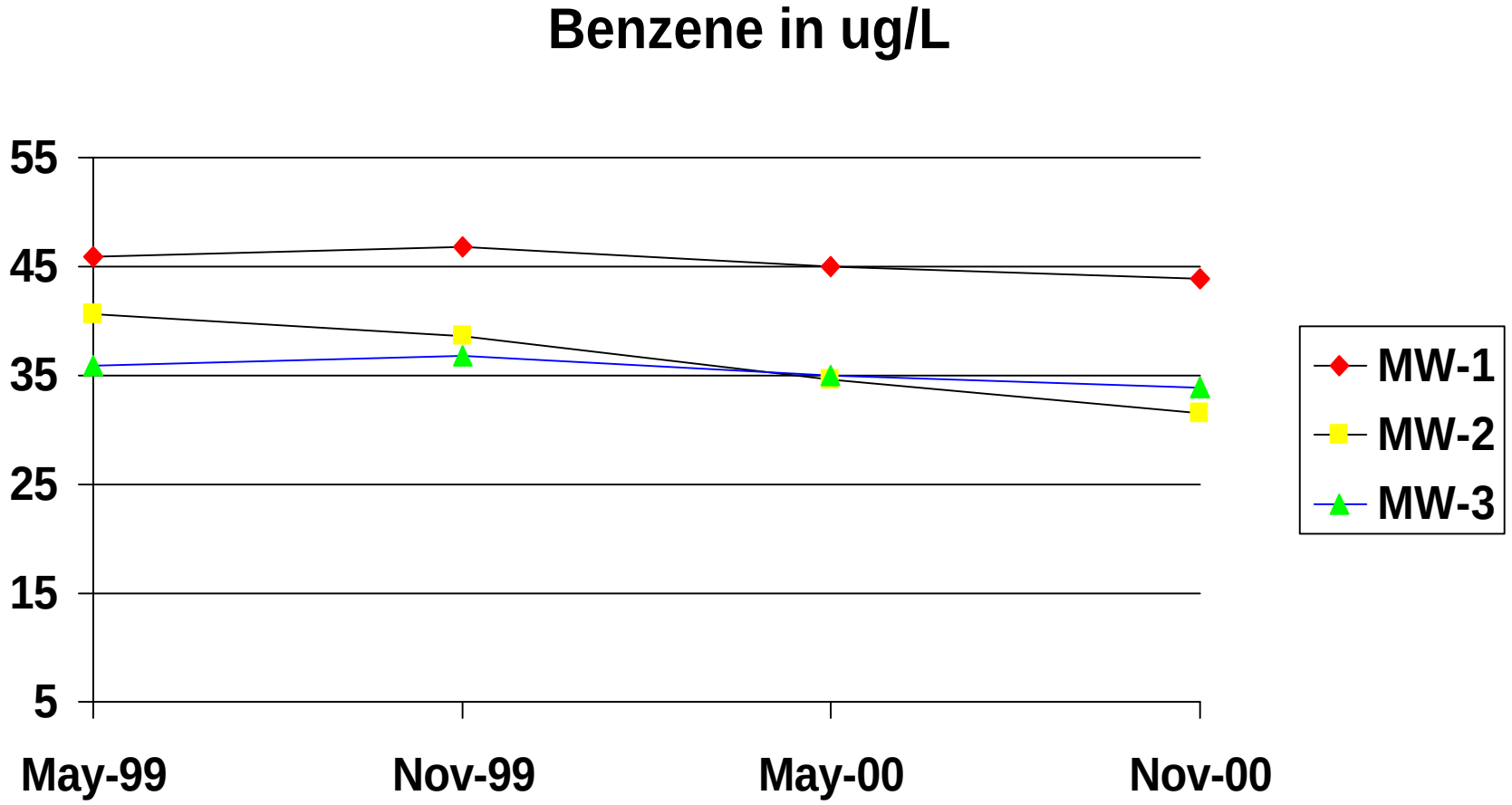


- Where to measure
  - Compliance: GW at selected monitoring points, up- and down-gradient and in the plume
  - Performance: GW or soil in root zone, and perhaps plant tissue
  - Probably shallow sample depths

Specific Technologies: Phytoremediation (Concluded)

- What to measure (GW and maybe soil)
  - If Phyto is uptake/extraction system, then measure contaminant(s) affected before, after, and during
  - If Phyto is bio-stimulation/transformation system, also measure anticipated reaction products
- What to expect
  - Remedy *takes time*, but lowers [C] eventually
- Trick
  - Give it time, and trend/chart progress
- Recommendation
  - Use computer modeling to assist performance interpretation

Visual Example: Phytoremediation



Specific Technologies: Bioremediation--Enhanced

- **Where to measure (Compliance and Performance)**
  - **Specific points at or within the range of influence of stimulant addition**
  - **Others depend on goal of enhancement**
    - **If hot spot remediation, then at those spots**
    - **If plume stabilization, then perimeter points**
- **What to measure (GW)**
  - **Contaminants being affected for 1st-line evidence of plume stabilization (such as TCE)**
  - **Reaction precursors and products for 2nd-line evidence of biodegradation (vinyl chloride & ethene)**

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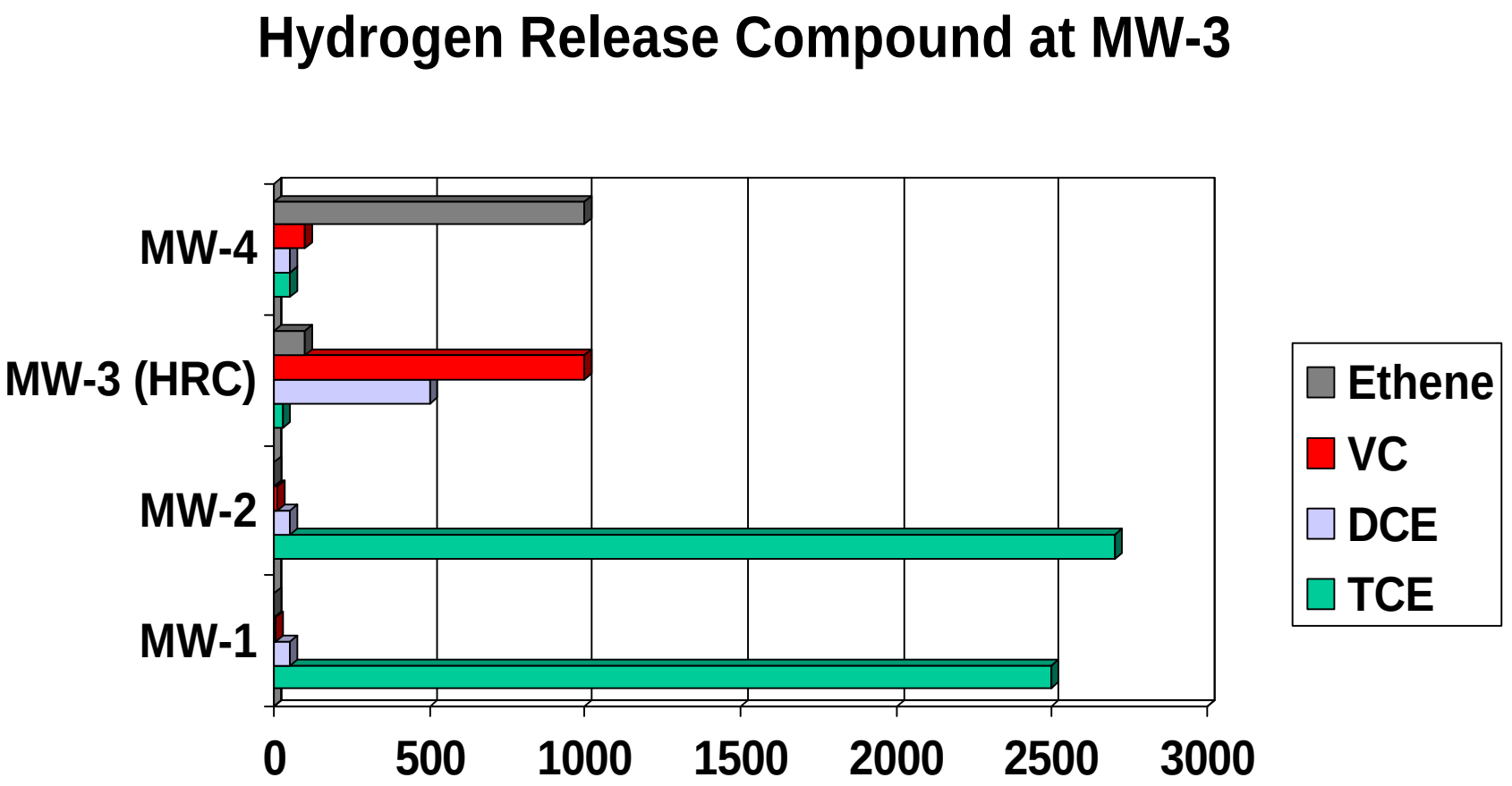
Specific Technologies: Bioremediation—Enhanced (Concluded)

- **What to expect**
  - **A dynamic system**
  - **If it works effectively, outcome will be noticeable**
- **Tricks**
  - **Use field measurements whenever possible**
  - **Use visualization techniques to assist interpretation**
- **Rules**
  - **Reaction products may be of concern**
  - **Measure what is needed to use computer modeling**

Visual Example: Bioremediation--Enhanced



Specific Technologies: Monitored Natural Attenuation

- Where to Measure (Compliance and Performance)
  - At specific points in plume and along the perimeter
    (May need monitor wells down centerline of plume)
  - Infrequent sampling or sampling directed by decision-logic diagram

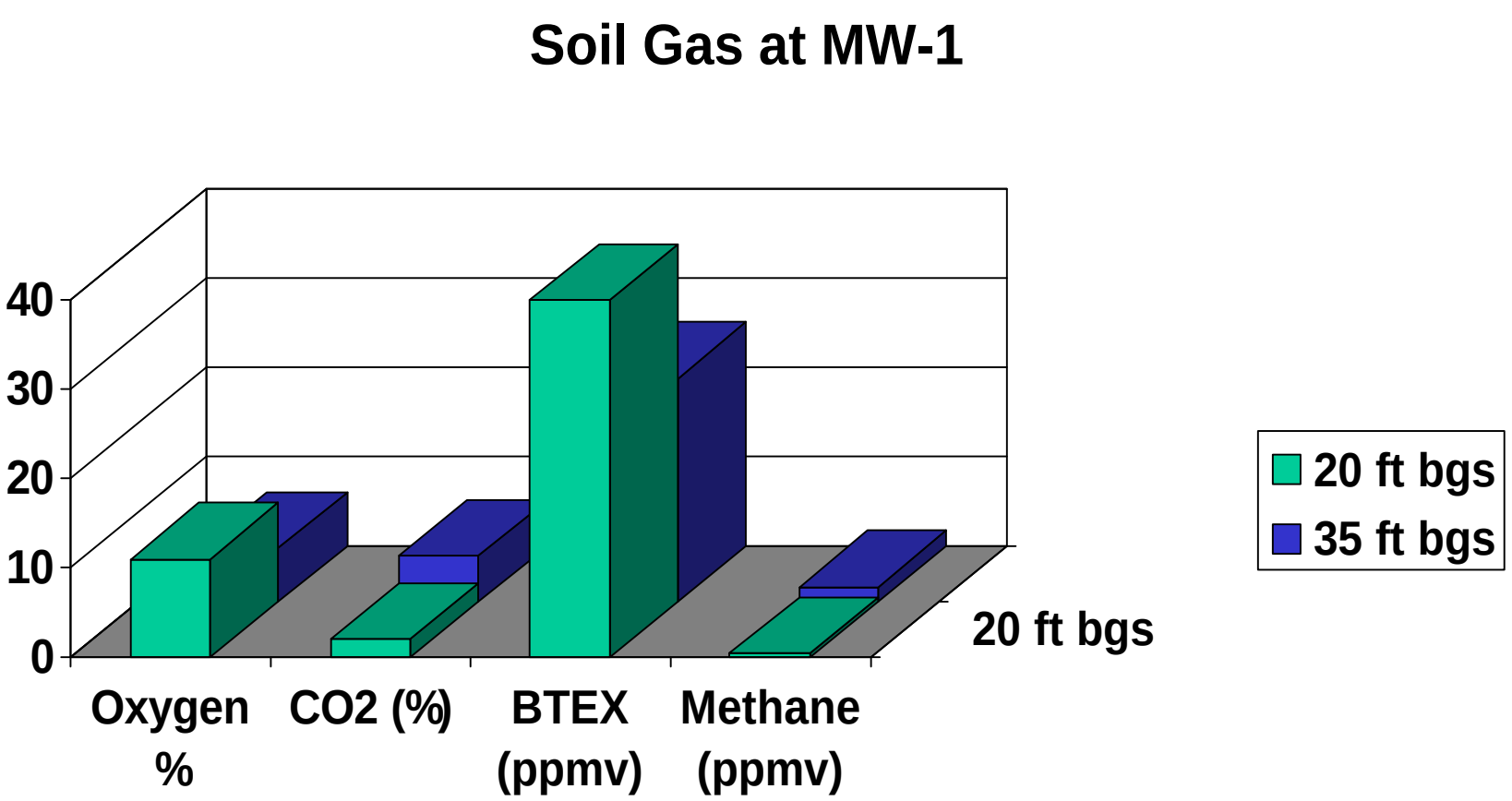
Specific Technologies: Monitored Natural Attenuation

- **What to measure (GW or soil gas)**
  - **Contaminants being affected for 1st-line evidence of plume stabilization (such as BTEX)**
  - **Reaction precursors and products for 2nd-line evidence of biodegradation (oxygen/carbon dioxide)**
- **What to expect**
  - **It will work on fuel constituents and on TCE in the presence of fuels or a degradable carbon source**
  - **Changes will *take time* and will be *small***

Specific Technologies: Monitored Natural Attenuation (Concluded)

- **Tricks**
  - **Calculate assimilative capacity of system**
  - **Measure reaction precursors/products in the field (Potential for rapid changes in form and/or concentration in the samples)**
- **Recommendation**
  - **Use models for data interpretation**

Visual Example: Monitored Natural Attenuation



Specific Technologies: Soil Vapor Extraction

- Where to Measure
  - Compliance: Process points, especially in and out of treatment system
  - Performance: selected monitoring and extraction points

Specific Technologies: Soil Vapor Extraction

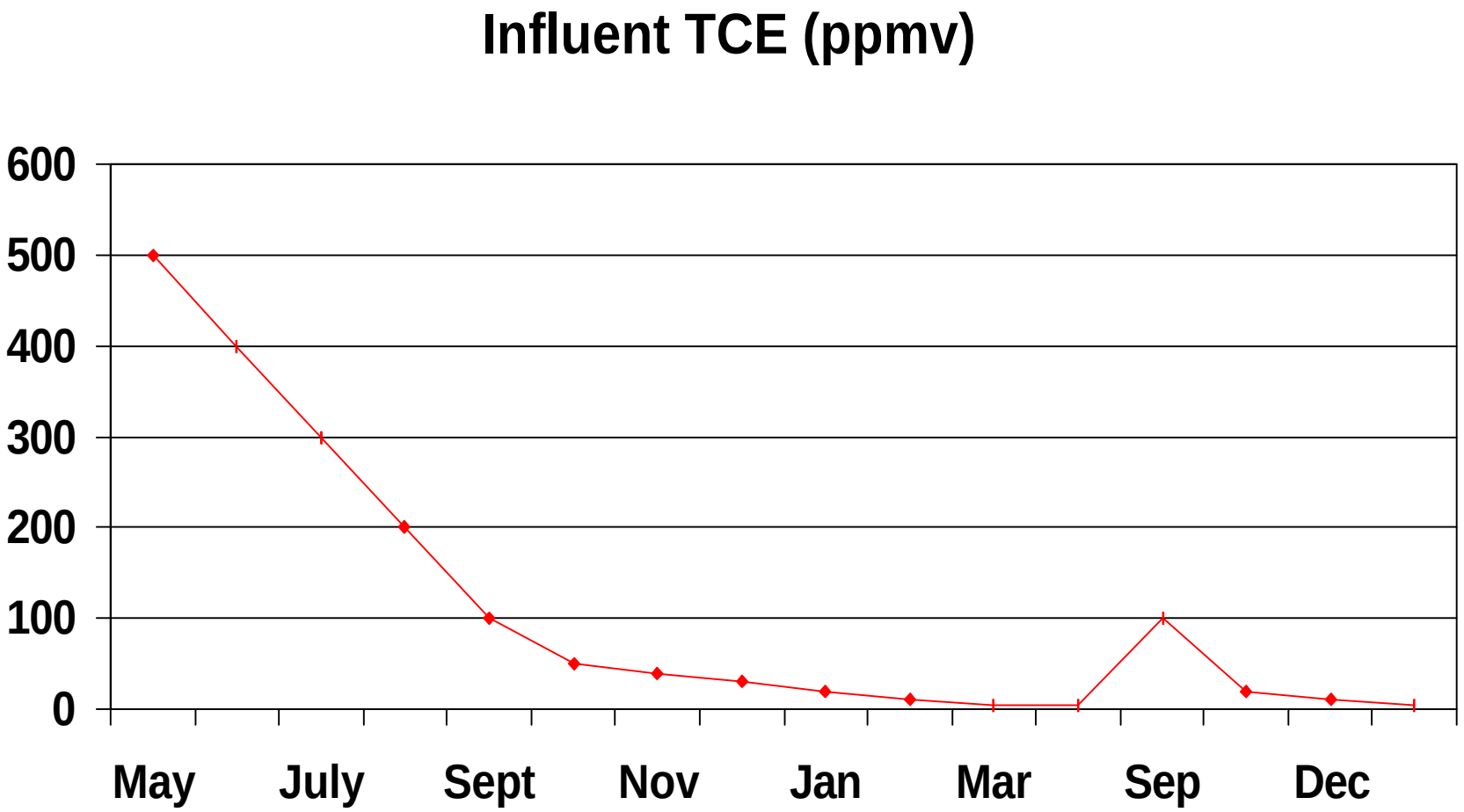
- What to measure (soil gas)
  - Gaseous contaminants of concern (COCs), short list
  - 'Fixed' gases, such as oxygen and carbon dioxide
  - If treatment is thermal, measure criteria pollutants oxides of nitrogen and sulfur
  - If measuring chlorinated VOCs and thermal, need hydrochloric acid gas
- What to expect
  - Dynamic, rapid changes initially
  - Will reach asymptotic levels with time
  - Will remove more mass than initially estimated

Specific Technologies: Soil Vapor Extraction (Concluded)

- **Tricks**
  - **Have *consensus* strategy to transition out of SVE**
  - **Use field instruments w/some laboratory data**

- **Recommendations**
  - **Develop consensus rebound decision rules**
  - **Have consensus exit strategy for site (could include some soil sampling and analyses)**

Visual Example: Soil Vapor Extraction



Specific Technologies: Pump & Treat--Groundwater

- Where to Measure
  - Compliance: process points, especially in and out of treatment system
  - Performance: selected monitoring and extraction points

Specific Technologies: Pump & Treat--Groundwater

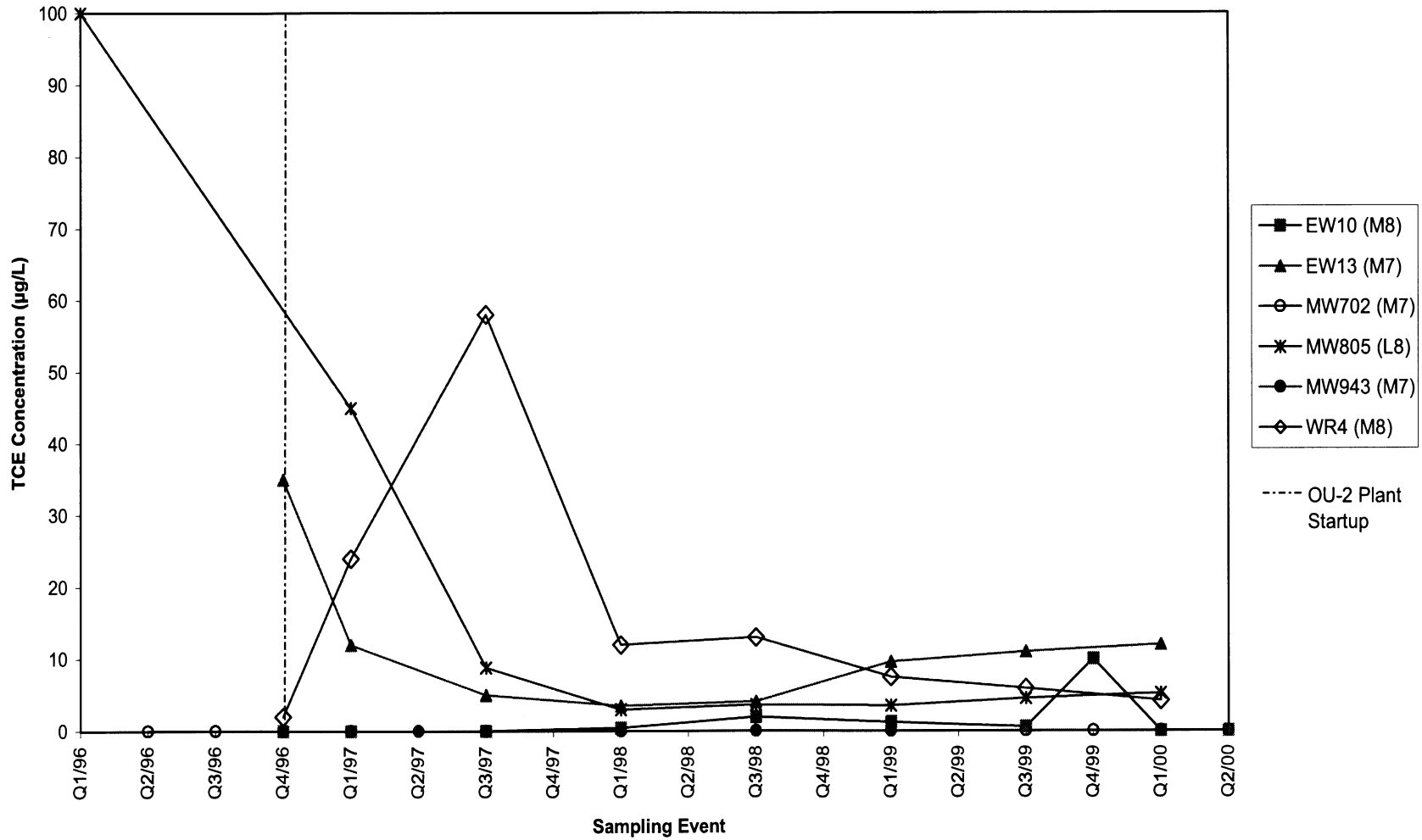
- What to measure (GW)
  - COCs (short method analyte list)
  - Mostly laboratory data
  - Process measurements dependent on treatment technology (for carbon just in and out, for air stripping/thermal may also need acid gases)
- What to expect
  - You're in it for the long-haul
  - In some cases, P&T could be the final remedy

Specific Technologies: Pump & Treat—Groundwater (Concluded)

- **Tricks**
  - **Have *consensus* strategy to transition out**
  - **Use integrated plume management strategy**

- **Recommendations**
  - **Continuously optimize monitoring and treatment process and review annually**
  - **Have consensus exit strategy for site**

Visual Example: Pump & Treat--Groundwater



Specific Technologies: Dig and Haul

- Where to Measure (Compliance and Performance)
  - For Dig--grab/composite samples to confirm all COCs below action levels
  - If Haul is treated, then before/after treatment
  - Sample to verify fill is free of contaminants

Specific Technologies: Dig and Haul

- What to measure (soil)
  - COCs above action levels
  - Use field screening to verify vertical/lateral extent removed before confirmation sampling
  - Confirmation samples w/rapid turns in laboratory

- What to expect
  - Will remove more soil volume than originally estimated
  - Uncomplicated data interpretation (if all below action)

Specific Technologies: Dig and Haul (Concluded)

- Tricks
  - Use field screening before final confirmation samples
  - Use statistical or composite sampling approach to reduce number of samples analyzed

- Recommendations
  - Have decision rules for situation where confirmation samples above action levels
  - Have decision rules when haul is treated

Specific Technologies: Landfill Cover

- Where to Measure (Compliance and Performance)
  - GW: points up- and down gradient
  - Gas:points on and off landfill
  - Leachate: points at leachate collection system
  - Periodic cover competency survey

Specific Technologies: Landfill Cover

- What to measure
  - GW: COCs
  - Gas: Methane, VOCs—do in field
  - Negotiate shortened method analyte lists
- What to expect
  - Long-term monitoring
  - Fairly complicated data interpretation for GW

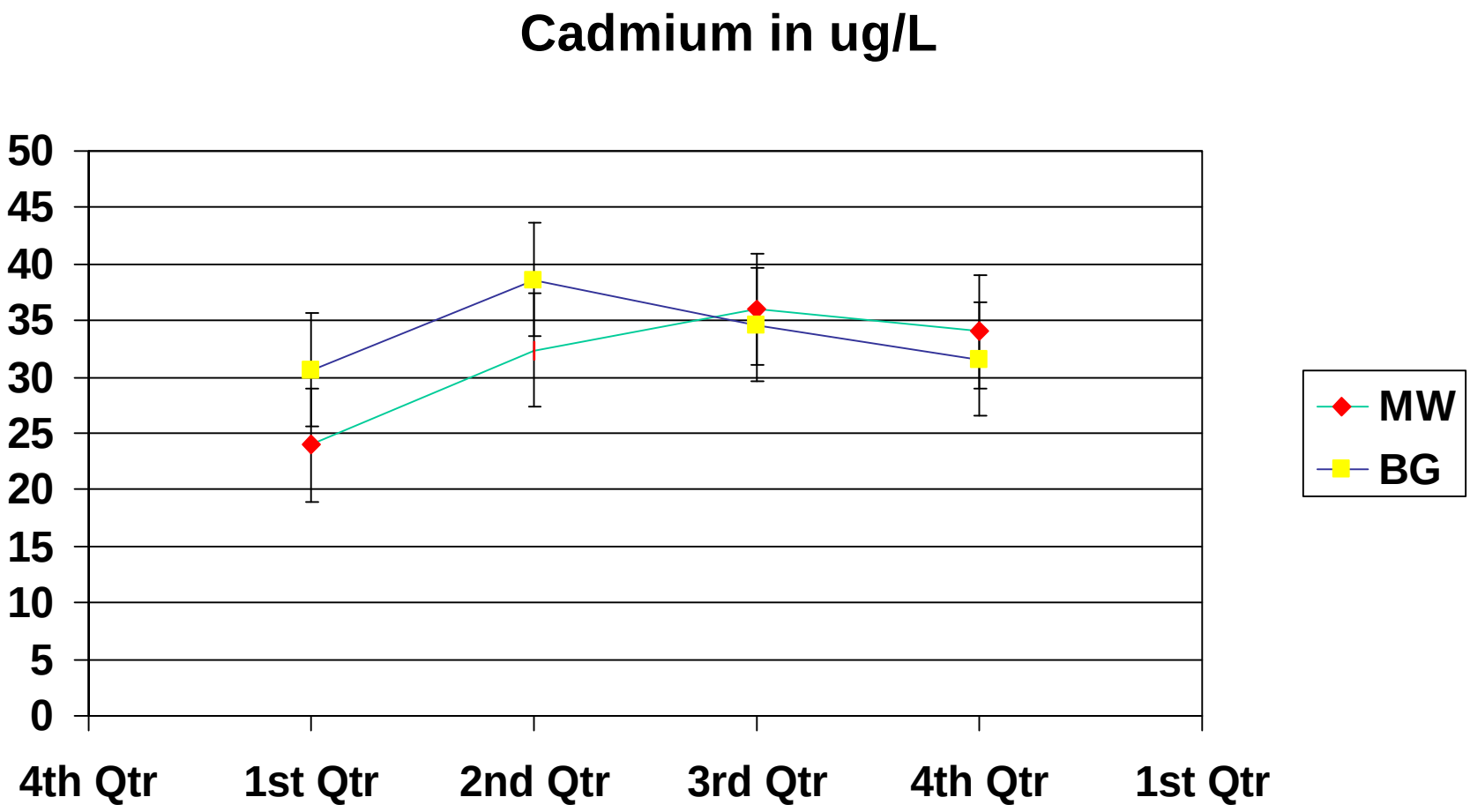
Specific Technologies: Landfill Cover (Concluded)

Tricks

- **Use field measurements as much as possible**
- **Do not do it at all (??)**

- **Recommendations**
  - **Optimize long-term monitoring decision rules and sampling & analysis decision tree**
  - **Use simple, understandable data analysis statistics and visualization tools**

Visual Example: Landfill Cover



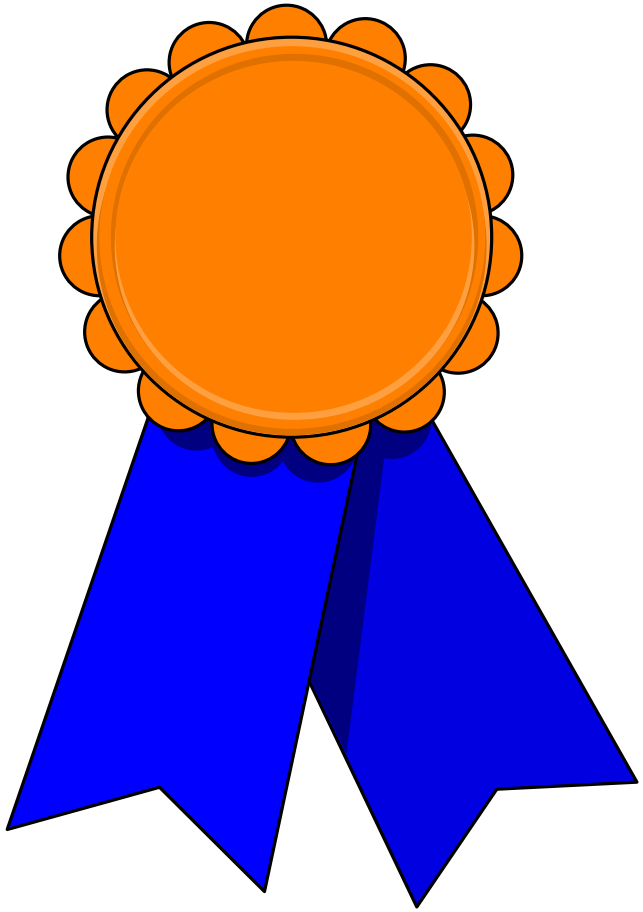
Specific Technologies: Summary

- Take samples that represent the remedy process
- Use number and frequency commensurate with the process' timeline and conceptual model
- Measure only those constituents needed for decision making
- Whenever possible, measure constituents in the field
- Expect many of these remedies to take time to perform and exhibit measurable performance
- KISS
- Always have consensus change and exit strategies

Measuring Performance: Conclusions

- Understand *where, why*, & *what* you are measuring
- Develop & document consensus decision rules
- Keep It Simple Stupid
- Measure constituents in the field
- Optimize, optimize, optimize

↯ All of these to save time and minimize costs



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References and WEB Sites

- Various AFCEE protocols on LTM optimization, process optimization, bioremediation can be found at www.afcee.brooks.af.mil/er
- Field Analytical Technologies Encyclopedia can be found at fate.clu-in.org
- Natural attenuation material can be found at www.api.org/ehs
- Phytoremediation material can be found at www.gwrtac.org
- General remedy information and guidance material can be found at www.epa.org and www.frtr.gov